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Economies of Scale and Organization  
Efficiency in Banking

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*Walter J. Primeaux, Jr.*

*Morgan J. Lynge, Jr.*

*Paul Newbold*



# **BEBR**

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Economies of Scale and Organization Efficiency in Banking

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## ABSTRACT

### Economies of Scale and Organization Efficiency in Banking

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A number of previous studies have attempted to assess the extent to which economies of scale exist within banking firms. Most of these studies have relied upon cost functions of one form or another and their findings have been inconclusive. A major difficulty involved in the cost function approach is the selection of an appropriate measure of bank output.

The profit function and its duality relationship with the production function offer an alternative approach to examining economies of scale and organizational efficiency in commercial banking. This alternative enjoys several advantages over the cost function method, consequently, that is the approach used in this study.

A risk adjusted profit function is used in the estimation of economies of scale of unit and branch banks; and the effects of bank holding company affiliation on the level of bank profits is also examined. The results indicate larger economies of scale for branch banks than for unit banks and bank holding company affiliates were found to be more efficient than independent banks.

\* The authors are Vice President Thai Farmers Bank; and Professor of Business Administration, Associate Professor of Finance, and Professor of Economics at the University of Illinois at Urbana-Champaign.



# ECONOMIES OF SCALE AND ORGANIZATION EFFICIENCY IN BANKING

By

Warapatr Todhanakasem, Walter J. Primeaux, Jr.,  
Morgan J. Lynge, Jr., Paul Newbold

## INTRODUCTION

After Alhadeff's [1954] pioneering work on bank costs, several empirical studies were conducted to examine economies of scale in commercial banks. Most of these studies relied upon cost functions of one form or another and their findings have been inconclusive about the existence of economies of scale in banking. A major difficulty involved in the cost function approach is the selection of an appropriate measure of bank "output." Benston (1965, 1972), Bell and Murphy (1968), and Murphy (1972) utilized physical measures of Bank outputs in estimating cost functions. Powers (1969), Longbrake and Haslem (1975), Langer (1980), and Kalish and Gilbert (1973) used either multiple output measures or an index with multiple weighted components as a measure of output. Research results have been highly sensitive to the choice of output variables.

Development of the profit function and its duality relationship with the production function<sup>1</sup> offer an alternative approach to the study of economies of scale and organizational efficiency in commercial banking. Advocates of this approach explain that it is more desirable than the cost function because the level of output is not a variable in the profit function. Furthermore, the procedure also captures a more complete concept of efficiency than the cost function approach.

Mullineaux (1978) tested a hybrid profit function which is transcendental logarithmic (translog) in labor input prices and Cobb-Douglas in the prices of output and other inputs and the quantities of fixed factors of production.<sup>2</sup> His samples contained banks participating in the Functional Cost Analysis Program in 1971 and 1972. However, the Functional Cost Analysis data which he used have often been criticized as not being representative of the banking industry, since participation is voluntary and most of the data tend to be from small banks.

The main purpose of this study is to conduct separate empirical tests of banking economies of scale and organizational efficiency, utilizing a risk-adjusted profit function on randomly-selected samples of unit and branch banks. The contributions of the work compared with previous research consist of the use of more recent data (1978, 1979, 1980), the introduction of elements of risk into the profit function, and the development of separate estimations for banks operating under different branching arrangements (unit and branch banks).

#### PROFIT FUNCTION

The profit function approach offers a convenient analytical tool which captures both the technical efficiency and price efficiency dimensions of economic efficiency. Technical efficiency deals with the quantity of output produced from a given level of inputs. Price efficiency deals with the quantity of profit produced from a given level of technical efficiency.<sup>3</sup>

Following McFadden (1966) and Lau and Yotopoulos (1971), profit is defined as current revenue less current total variable cost.<sup>4</sup> The



profit function expresses a firm's maximized profit as a function of the prices of output and variable inputs and the quantities of fixed factors. The derivation of the profit function assumes that the firm is a price-taker in both the output and variable input markets. It also assumes that the quantities of fixed factors are given. The last assumption implies profit maximization in the short run, and the profit function thus derived is called the "restricted profit function."<sup>5</sup>

Duality was developed by Hotelling [1932], Shephard [1953], and Uzawa [1964]. McFadden [1966] later demonstrated that it is possible to consider only the profit functions in analyses of profit-maximizing, price-taking firms without explicitly specifying their corresponding production functions.

In the context of the profit function theory, the goal of an individual commercial bank is to maximize profits by taking deposits or borrowing funds and converting them into various types of earning assets. Banks also provide other financial-related services, for example, safe deposit boxes, for fees. In the regular conduct of their business, banks expose themselves to many kinds of risk.

On the asset side of the balance sheet, assets held by a bank can be divided into two broad classes: earning assets and non-earning assets. Given the characteristics and distribution of its liabilities, the bank attempts to structure its portfolio of assets in such a manner as to yield the greatest return. The higher the percentage of the bank's total assets held in earning assets, the greater is its expected profit, *ceteris paribus*.<sup>6</sup>

It is desirable to distinguish between the ex ante and the ex post measures of risk. When granting a loan a bank can only make a subjective judgment of the risk of it culminating in default. The higher the probability of default, the riskier is the loan and the higher the rate of interest charged by the bank. The ex ante measures, essentially, are the characteristics of a portfolio that would indicate the actual performance. If the risky loans turn out to have lower default rates than expected, the bank will realize higher than expected profits and vice versa.<sup>7</sup>

Most studies of risk have traditionally used the variance or covariances of earnings as measures of riskiness.<sup>8</sup> These measures are ex post in nature. Rhoades [1981] argued that a good ex ante measure of the bank portfolio risk is the ratio of total loans to total assets because it is generally accepted that loans tend to be riskier than other types of assets typically held by a bank.<sup>9</sup>

In the framework of the profit function, the loans to assets ratio can be viewed as a variable input factor. The higher ratio means higher portfolio risk exposure. If the cost due to defaulted loans is high, realized profit for this period will be low, and vice versa.

Banks are exposed to risk on the liability side of their balance sheets as well. We consider the two broad categories, namely, liabilities and equity capital. For equity capital, the ratio of equity to total assets has been a popular ratio used by bank regulators as a measure of bank soundness.<sup>10</sup> As the ratio rises, the bank's financial

risk is reduced. For liabilities, as the bank relies less on traditional (stable) deposits and more on borrowed sources of funds from the money market, the ratio of borrowed funds to total liabilities rises and the bank is subject to greater liquidity risk. Management policy on liabilities and equity capital, therefore, can have significant impacts on the risk and profitability on the bank. During periods of tight money, for example, bank equity capital, as an indefinite term-to-maturity source of funds, can reduce the bank's exposure to high borrowing costs and disintermediation.<sup>11</sup> If banks are faced with rising short-term money market costs of funds that cannot be passed on to the borrowing customers through floating rates on loans, then banks that depend largely on borrowed funds from the money markets may suffer seriously from leverage risk.<sup>12</sup> At other times general interest rates in the money market may decline and banks may benefit from access to cheaper costs of borrowed funds.

Over a period of time the bank's ratio of equity capital to total assets and its ratio of borrowed funds to liabilities can be considered variable cost factors which, depending on market conditions and the bank's liability and equity positions, may cause high or low realized bank profits.

Hence, we use three measures of risk from both sides of the balance sheet: the ratios of total loans to total assets, equity capital to total assets, and borrowed funds to total liabilities.<sup>13</sup>

# THE MODEL AND DATA

The full Cobb-Douglas specification has properties which make it convenient for economies of scale estimation. Lau and Yotopoulos [1971] have proved that, given the Cobb-Douglas production function conditions, differences in technical efficiency and/or differences in price efficiency translate into constant differences in the level of profits, given market prices. They have also proved that a test of the hypothesis of constant returns in all inputs is a test of the hypothesis  $\sum_{i=1}^b \beta_i^* = 1$ , where the  $\beta_i^*$ 's are the elasticities of the profit function with respect to the fixed factors of production.<sup>14</sup> This property allows us to test for scale economies or diseconomies by adding the coefficients of all the fixed factors of production to see whether the sum is equal to, or larger or small than unity.

The Cobb-Douglas risk-adjusted profit function model that will be used for our estimations is:

$$\ln \text{PROFIT} = a_0 + \sum_{i=1}^m a_i \ln P_i + \sum_{j=1}^n b_j \ln q_j + \sum_{k=1}^w c_k \ln Z_k$$

where  $P_i$  are the bank output prices,  $q_j$  are the variable input prices, including risk factors, and  $Z_k$  are the quantities of fixed factors.

All data were obtained from the FDIC computer tapes containing balance sheet and income statement data for all insured banks for 1978-1980. All balance sheet data are measured as annual average values. The years 1978-1980 were chosen for this empirical work because during the first two of these years the banking industry had



returned to a relatively normal operating condition following the turbulent periods during and immediately after the recession of 1974-1975. Interest rates were rising steadily and became much more volatile in 1980. Competition intensified in several areas of the banking industry; commercial banks were faced with aggressive competition from the finance companies in the business loan market and from the thrift institutions and finance companies in the consumer loan market.

To examine how banks of different sizes and forms of organization fared during the period of relatively stable economic condition and increasing competition in the industry, we test two specifications:

Equation for Unit Banks

$$\begin{aligned} \ln \text{ PROFIT} = & \ln a + b_1 \ln \text{ LRATE} + b_2 \ln \text{ ATW} \\ & + b_3 \ln \text{ INTTS} + b_4 \ln \text{ INTCD} + b_5 \ln \text{ TLTA} \\ & + b_6 \ln \text{ EQTA} + b_7 \ln \text{ BFLB} + b_8 \ln \text{ PREM} \\ & + b_9 \ln \text{ TD} + b_{10} \ln \text{ LB} + b_{11} \ln \text{ SWB} + b_{12} \ln \text{ BHC} \end{aligned}$$

Equation for Branch Banks

$$\begin{aligned} \ln \text{ PROFIT} = & \ln a + b_1 \ln \text{ LRATE} + b_2 \ln \text{ ATW} \\ & + b_3 \ln \text{ INTTS} + b_4 \ln \text{ INTCD} + b_5 \ln \text{ TLTA} \\ & + b_6 \ln \text{ EQTA} + b_7 \ln \text{ BFLB} + b_8 \ln \text{ PREM} \\ & + b_9 \ln \text{ TDBR} + b_{10} \ln \text{ BR} + b_{11} \ln \text{ LB} + b_{12} \ln \text{ BHC} \end{aligned}$$

where

PROFIT = total operating revenue minus total operating expenses

LRATE = average rate of interest and fees on total loans

ATW = average total wages per full-time equivalent employee

INTTS = average interest rate on time and savings deposits

INTCD = average interest rate on large certificate of deposits

TLTA = ratio of total loans to total assets

EQTA = ratio of equity capital to total assets

BFLB = ratio of borrowed funds to total liabilities

PREM = bank premises and furnitures and fixtures

PREMBR = average bank premises per branch

BR = number of branches<sup>15</sup>

TD = total deposits

TDBR = total deposits per branch

LB = limited-branching state dummy variable (1 = limited  
branching state; 0 = otherwise)

SWB = statewide-branching state dummy variable (1 = statewide  
branching state; 0 = otherwise)

BHC = bank holding company affiliation dummy variable (1 =  
affiliated bank; 0 = independent bank)

These profit function specifications assume that banks are price takers in output and variable input markets but allow for an empirical test of this assumption. If banks are not price takers in the output market, output prices will not be significant explanatory variables in the profit function. The output price variable, therefore, is expected to have a positive and significant coefficient.<sup>16</sup>

As the theory of the profit function suggests, the expected signs for the coefficients of the quantities of the fixed factor variables are positive. That is, as a bank increases its premises, deposits, or number of branches, profits should increase. The signs for the coefficients of variable input prices other than the risk factors are expected to be negative. That is, as the variable costs increase profits are expected to decline.

The expected signs for the coefficients of the risk factors, however, need some further elaboration. As discussed earlier, the total loans to total assets ratios (TLTA), as an ex ante measure of risk, may produce either a positive or negative effect on actual bank profits, depending on the actual performance of the loans. The coefficient of EQTA is expected to have a positive sign because as the ratio increases the bank avoids paying "outright" interest as would be necessary on deposits or borrowed funds. Since our measure of profits is total revenue less total operating expenses, which essentially is income before dividend payments, the higher the ratio of equity capital to total assets (EQTA), the higher profit will be. Also, as the ratio of borrowed funds to total liabilities (BFLB) increases, the interest payments on borrowed funds grow and this is expected to have a negative effect on profits. Therefore, a priori the sign for the coefficient of BFLB is negative.

Most previous studies have suggested that the holding company form of organization in commercial banking is more profitable than the non-holding form.<sup>17</sup> These findings are reasonable because bank holding

companies have access to more diverse business opportunities than banks which are restricted to only "pure" banking business. Consequently, the coefficient for BHC is expected to have a positive sign.

The unit bank sample contains mainly banks from unit banking states but also include some unit banks drawn from states permitting limited or statewide branching. A bank which operates a single office in an environment where some forms of branching are allowed would be expected to earn lower profits because it fails to exploit the larger geographical market opportunities and also must face strong competition from other branch banks. The expected signs for the coefficients of LB and SWB, therefore, are expected to be negative for the unit bank equation. For the branch bank equation, only branch banks located in the LB or SWB states were included in the sample. It could probably be argued that branch banks in LB states may face less competition than those operating in SWB states. If this is correct, branch banks located in the LB states would be expected to have higher profits.

## EMPIRICAL RESULTS

### Unit Banks

The results reported in Table 1 show that the coefficients of the output price variable (LRATE) consistently take positive values and are statistically significant. These results are as expected and support our assumption that banks are price takers in the output market.



The average coefficient over the three-year period is 1.224, indicating that a 1 percent increase in the average loan rate would yield a 1.224 percent increase in bank profits. Average total wages per full-time equivalent employee (ATW), however, has unexpected positive coefficients for all three years; however, none of the values are statistically significant.

Variable input prices both of the average interest rates on time and savings deposits (INTTS) and large CD's (INTCD) have expected negative coefficients for all years. However, only the coefficient of INTTS in the 1979 equation is statistically significant.

For the risk factors, the ratio of total loans to total assets (TLTA) has negative coefficients for all years but is significant only in the 1979 equation. This seems to indicate that unit banks that held a large portion of their earning assets in the form of loans during 1979 actually realized lower profits than unit banks whose portfolio risk was smaller. The ratio of equity capital to total assets (EQTA) produces the expected coefficients which are positive and statistically significant. The ratio of borrowed funds to total liabilities (BFLB), on the other hand, does not have a significant coefficient, although the coefficient signs are negative, as expected, for two of the three years.

As for the fixed factors, it is interesting to note that the coefficients of bank premises (PREM) are negative and statistically significant. These seem to suggest that, given the level of business, unit banks either overinvested in fixed physical facilities and equipment,

TABLE 1  
OLS REGRESSION RESULTS FOR UNIT BANKS<sup>(a)</sup>

Variable	1978	1979	1980	Average
LRATE	.915*** (.195)	1.046*** (.159)	1.712*** (.208)	1.224
ATW	.042 (.099)	.101 (.079)	.123 (.101)	.089
INTTS	-.199 (.141)	-.409*** (.134)	-.093) (.112)	-.234
INTCD	-.039 (.042)	-.056 (.034)	-.003 (.045)	-.033
TLTA	-.077 (.081)	-.138* (.073)	-.124 (.085)	-.113
EQTA	.589*** (.088)	.780*** (.079)	1.109*** (.108)	.826
BFLB	-.010 (.019)	.013 (.017)	-.010 (.020)	-.002
PREM	-.163*** (.028)	-.150*** (.024)	-.082*** (.031)	-.132
TD	1.285*** (.042)	1.154*** (.035)	1.107*** (.044)	1.182
LB	.042 (.046)	-.058 (.041)	.008 (.048)	-.003
SWB	-.060 (.090)	-.184*** (.058)	-.162** (.074)	-.135
BHC	.099** (.048)	.115*** (.038)	.202*** (.047)	.139

Variable	1978	1979	1980	Average
Intercept	-3.337*** (.669)	-1.936*** (.577)	.963 (.684)	-4.31
N	547	542	531	
$\bar{R}^2$	.7751	.8139	.7492	
S.E.	.4577	.3730	.4668	
F	157.824	198.107	132.951	

(a) standard errors in parentheses  
 \*\*\* significant at the 1 percent level  
 \*\* significant at the 5 percent level  
 \* significant at the 10 percent level

or failed to utilize the premises for the profit maximization objective. On the other hand, the deposit base variable (TD) has coefficients that are positive and statistically significant with magnitudes larger than unity for all three equations. Total deposits, therefore, provide the sources of loanable funds which help generate enough profits to offset any tendency toward diseconomies of scale which may exist in the use of premises.

Overall, the banks turn out to have slight scale economies. If a unit bank increases its premises and total deposits in the same proportions, the overall economies of scale are 1.122, 1.004 and 1.025 for 1978, 1979 and 1980 respectively, with the average value of 1.05. These figures indicate that unit banks do enjoy some modest economies of scale.

The coefficients of SWB and BHC indicate that (1) unit banks in statewide branching states are less profitable than unit banks in unit banking states, and (2) banks affiliated with holding companies are more profitable than independent banks.

#### Branch Banks

Regression results for branch banks are reported in Table 2. Like the unit bank equations, the output price variable (LRATE) generates coefficients which are positive and statistically significant. The average value is 1.45, slightly above the 1.22 average of the unit bank equations. Also resembling the pattern results of the unit banks are the coefficients of (ATW), and the other variable input prices, the average interest rates on time and savings deposits (INTTS) and on CD's (INTCD).



TABLE 2

OLS REGRESSION RESULTS FOR BRANCH BANKS<sup>(a)</sup>

Variable	1978	1979	1980	Average
LRATE	1.236*** (.222)	1.293*** (.290)	1.837*** (.286)	1.445
ATW	.048 (.110)	.076 (.152)	-.103 (.119)	.007
INTTS	.366** (.157)	-.480** (.212)	-.269 (.237)	-.128
INTCD	-.004 (.044)	-.111* (.060)	-.087 (.069)	-.067
TLTA	.132 (.103)	.162 (.155)	.108 (.158)	.133
EQTA	.863*** (.085)	.882*** (.117)	1.051*** (.130)	.932
BFLB	-.015 (.021)	-.041 (.030)	-.030 (.036)	-.029
PREMBR	-.273*** (.036)	-.256*** (.050)	-.267*** (.051)	-.265
TDBR	1.359*** (.046)	1.316*** (.061)	1.289*** (.063)	1.321
BR	1.049*** (.023)	1.023*** (.033)	1.004*** (.035)	1.025
LB	-.025 (.036)	.031 (.050)	-.006 (.052)	0
BHC	.083** (.041)	.134** (.054)	.032 (.055)	.083

TABLE 2  
(continued)

Variable	1978	1979	1980	Average
Intercept	-.188 (.794)	-2.568** (1.000)	.417 (.997)	-.780
N	509	489	478	
$\bar{R}^2$	.8602	.7685	.7447	
S.E.	.3965	.5212	.5377	
F	261.447	135.984	116.939	

(a) standard errors in parentheses

\*\*\* significant at the 1 percent level

\*\* significant at the 5 percent level

\* significant at the 10 percent level

Among the three risk factors, only (EQTA) consistently yields coefficients with the hypothesized positive signs that are also statistically significant. Again, these results resemble those of the unit banks' and suggest that both unit and branch banks realize higher profits as they use less leverage. (TLTA) and (BFLB), however, do not generate coefficients which are statistically different from zero.

The coefficients of the three fixed factors (namely, PREMBR, TDBR, and BR) add up to 2.135, 2.083, and 2.026 for 1978, 1979 and 1980 respectively, with an average of 2.08. These values are approximately twice those of the corresponding unit bank equations. They suggest that branch banks realize greater economies of scale than unit banks and that the major sources of scale economies are the total deposits per branch and the number of branches. Like unit banks, branch banks' premises per branch are also the sources of diseconomies. Its coefficients are negative and significant for all years with an average value of  $-.27$ .

The coefficients on (LB) and (BHC) indicate that (1) the profit of branch banks in limited branching states is not significantly different from branch banks in statewide branching states, and (2) branch banks affiliated with holding companies have greater profit than independent branch banks.

#### Test of Equality of Coefficients

Like other industries, commercial banks experienced changes during the period 1978-1980. To examine whether the behavior of commercial banks has changed significantly, tests of equality of coefficients

were conducted on some variables for both the unit and branch banks.

Applying the normal distribution test of the difference between two means, with the null hypothesis that the two population means are equal, the Z-statistic is computed in our case as:

$$z = \frac{\beta_{i(80)} - \beta_{i(78)}}{\sqrt{s_{\beta_{i(80)}}^2 + s_{\beta_{i(78)}}^2}}$$

where  $\beta_{i(80)}$  = coefficient of variable i obtained from the 1980 equation, and

$\beta_{i(78)}$  = coefficient of variable i obtained from the 1978 equation.

Tables 3 and 4 show Z-statistics and significance levels only for the coefficients of variables which are statistically significant in both 1978 and 1980 in the unit bank equations and the branch bank equations respectively.

Table 3 shows that although the (BHC) variable is not found to contribute differently to unit bank profits in 1978 and 1980, statistically the Z-statistics for three other variables, (LRATE), (EQTA), (TD), are statistically significant at 5% or above and one variable, (PREM), at the 10% level. Table 1 shows that the coefficient of (LRATE) almost doubles its original value, increasing from .915 in 1978 to 1.712 in 1980. This is probably the result of banks adjusting their loan rates upward by amounts greater than the increased cost of funds. The coefficient of (EQTA) in 1980 is almost double its value in 1978. The coefficients of (LRATE) and (EQTA) in 1978 and 1980, therefore,

TABLE 3

TEST OF EQUALITY OF COEFFICIENTS OF UNIT BANKS  
Z-STATISTICS AND SIGNIFICANCE LEVELS

Variable	Z-Statistics	Significance Level
LRATE	2.80	.05
EQTA	3.69	.01
PREM	1.80	.10
TD	-2.83	.05
BHC	1.54	--

TABLE 4

TEST OF EQUALITY OF COEFFICIENTS OF BRANCH BANKS  
Z-STATISTICS AND SIGNIFICANCE LEVELS

Variable	Z-Statistics	Significance Level
LRATE	1.66	.10
EQTA	1.21	--
PREMBR	.10	--
TDBR	-.90	--
BHC	-1.08	--



provide some evidence that banks adjust their loan rates quite promptly and efficiently, while reducing their financial leverage during a period of rising market rates. Although the coefficients of PREM and TD are statistically different between 1978 and 1980, the magnitudes are relatively small. Together, they suggest that the reduction in economies of scale for unit banks from 1.122 in 1978 to 1.025 in 1980.

As for branch banks, Table 4 shows that only the coefficients of LRATE are significantly different between the two years. As in the case of unit banks, this indicates that branch banks also adjust loan rates upward to a greater extent than the increase in their costs of funds. Unlike unit banks, however, the coefficients of all other variables remain statistically unchanged. Therefore, branch banks appear not to have changed their behavior to the same extent as unit banks between the years 1978 and 1980.

#### CONCLUSIONS AND IMPLICATIONS

This work has dealt with the issues related to economies of scale, economic efficiency, and organizational efficiency in commercial banks. Through the application of the risk-adjusted profit function, we have estimated economies of scale of unit and branch banks and examined the effects of bank holding company affiliation on the level of bank profits. Separate estimations of unit and branch banks are more appropriate than the combined estimation because unit and branch banks are basically different in structure and operations.<sup>19</sup>

Overall, the results of this study indicate larger economies of scale for branch banks than unit banks. The levels of economies of scale for unit banks are also found to have declined between 1978 to 1980, although the magnitudes are small. Regardless of the branching status, bank holding company affiliates are found to be more efficient than independent banks.

These results have several implications for bank regulators and managers. Regulators should encourage (or at least not discourage) the branching form of organization. The greater economies of scale of branch banks occurs along with the greater number of offices in branching states, both beneficial to the bank customer.<sup>18</sup> Achieving branching via a limited branching arrangement is satisfactory because of the evidence that no greater efficiency occurs in statewide branching states. The increased efficiency of banks affiliated with holding companies should encourage the recent moves toward interstate banking.

At the bank level, both unit and branch banks should scrutinize their investment in premises and equipment. The evidence strongly suggests that banks have over invested in facilities or failed to utilize these physical facilities efficiently.

Notes

\*The authors are vice-president Thai Farmers Bank; and Professor of Business Administration, Associate Professor of Finance and Professor of Economics at the University of Illinois at Urbana-Champaign. An earlier version provides extensive detail of various aspects of the material shortened in this presentation, including the nature of the variables in the estimating equation, the data used and characteristics of the earlier studies. It is available from the authors on request.

<sup>1</sup>See McFadden [1966] and Lau [1969].

<sup>2</sup>Majumdar [1980] applied the profit function concept to the study of economies of scale of the 200 largest commercial banks in the U.S. in 1977. The profit function equations used, however, consisted of only one independent variable. Moreover, profit was defined as rate of return on assets rather than operating revenue minus operating expenses. A more sophisticated profit function study after Mullineaux can be found in the work of Richards and Villanueva [1980] which utilized the Philippines banking data.

<sup>3</sup>Lau [Reprint No. 269]: 206.

<sup>4</sup>Fixed costs are not considered because they do not affect the optimal combination of the variable inputs. See Lau and Yotopoulos [1971]: 97.

<sup>5</sup>See Varian [1978] for more detail. In the short run, some of the firm's inputs are fixed and only production plans compatible with these fixed factors are possible. Over the long run, however, these factors may be variable and the firm's technological possibilities may change.

<sup>6</sup>There have been a number of theoretical and empirical works on the relationship between risk and rate of return. For non-bank studies, see Cootner and Holland [1970] and Fisher and Hall [1969]. For a list of earlier works on risk and rate of return, see Fisher and Hall, *ibid.*, footnote 1. See also Heggstad [1977] for a similar study in banking.

<sup>7</sup>From the regulatory viewpoint, bank examiners regularly evaluate the quality of loans held by banks and formally classify or "criticize" some of the loans as "doubtful." Wu [1969] attempted to study the relationship of the "ex ante" data on the quality of bank loans, as measured by bank examiners criticism, and the "ex post" measure, which is the subsequent loan defaults. He found that the criticisms were "relatively accurate as an indicator of bank loan quality."

<sup>8</sup>See, for example, Fisher and Hall [1969], Cootner and Holland [1970], and Heggstad [1977].

- <sup>9</sup> Rhoades [1981]: 165.
- <sup>10</sup> See Mingo and Wolkowitz [1977]: 120.
- <sup>11</sup> See Pringle [1974].
- <sup>12</sup> See Wojnilower [1966] and Heimann [1981].
- <sup>13</sup> Rose and Scott [1978] use loans/assets, captial/loans, and volatile deposits/liabilities as measures of bank's business and financial risk.
- <sup>14</sup> Lau and Yotopoulos [1972]: 13-14.
- <sup>15</sup> The number of branches is a measure of plant size. See Richard and Villaneuva [1980].
- <sup>16</sup> A finding that bank output price makes no significant contribution to the empirical explanation of banking profits or yields a negative coefficient would suggest that banks are not price takers or that the equation is misspecified. See Mullineaux (1978): 263.
- <sup>17</sup> See, for example, Mayne [1977] and Graddy and Reuben Kyle, III [1980].
- <sup>18</sup> See Seaver and Fraser [1979]. For earlier related studies, see Horvitz and Shull [1964], Jacobs [1965], Lanzilotti and Saving [1969], and Savage and Humphrey [1979].
- <sup>19</sup> This proposition is also supported by a previous cost function study by Mullineaux [1975]. He rejected the hypothesis of identical coefficients of the variables for branch and unit banks.

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